DOCUMENT RESUME

ED 298 140 TM 012 023

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TITLE Confirmatory Maximum Likelihood Factor Analysis as Applied to Measures of Social Intelligence within the Structure-of-Intellect Model.
PUB DATE Apr 88
NOTE 12p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 5-9, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Behavior Patterns; *Factor Analysis; *Intelligence Tests; *Maximum Likelihood Statistics; Models; *Social Cognition
IDENTIFIERS *Confirmatory Factor Analysis; First Order Cognitive Analysis; Higher Order Skills; *Structure of Intellect

ABSTRACT

Confirmatory maximum likelihood factor analysis was used to determine how accurately each of several hypothesized combinations of first-order and/or higher-order factors could describe the covariation within selected sub-matrices taken from the total correlation matrix originally analyzed by M. O'Sullivan et al. (1965). Focus was on evaluating the goodness-of-fit of six models portraying different hypothesized factor structures and reproducing selected correlation sub-matrices established from a total correlation matrix of variables including both anchor tests or reasonably well-established factorial content and experimental measures of social intelligence designed to reflect selected constructs within the structure-of-intellect model of intelligence. Results indicate that: (1) confirmatory analysis permitted the reproduction of first- and higher-order factors within the social intelligence portion of the structure-of-intellect model; (2) a single higher-order or general factor of behavioral content constitutes a viable alternative to account for much of the covariance among the 23 measures of behavioral cognition that were tested; and (3) the first-order factors identified by O'Sullivan et al. were not supported. (TJH)

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# Confirmatory Maximum Likelihood Factor Analysis As Applied to Measures of Social Intelligence Within the Structure-of-Intellect Model

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AERA Spring 1988

TM012023

## Problem

The major purpose of this study was to ascertain through the use of confirmatory maximum likelihood factor analysis (Jöreskog, 1969; Jöreskog & Sörbom, 1984, 1986) how accurately each of several hypothesized combinations of first-order and/or higher-order factors could describe the covariation within selected submatrixes taken from the total correlation matrix originally analyzed by O'Sullivan, Guilford, and deMille (1965). Specifically, attention was directed to evaluating the goodness-of-fit of each of six models portraying different hypothesized factor structures and reproducing selected correlation submatrixes established from a total correlation matrix of variables including both anchor tests of reasonably well-established factorial content and experimental measures of social intelligence designed to reflect selected constructs within the Structure-of-Intellect (SI) model of intelligence (Guilford, 1967; Guilford and Hoepfner, 1971). This study was judged to be important because it afforded (a) an opportunity to gain an improved understanding of the nature of social intelligence, (b) a means for comparing two alternative factor analytic methodologies (exploratory versus confirmatory), and (c) a basis for identifying parsimonious constructs of social intelligence around which measures could be devised for assessment purposes in counseling and training programs.

To furnish the necessary background for understanding the meaning of the nine models representing nine hypothesized factor structures and the three research questions that serve to

generate statistical information for evaluating the factor models the information processing SI model provided the conceptual framework. Briefly, the SI model represents five types of content (stimulus input)--visual (V), auditory (A), symbolic (S), semantic (M), or behavioral (B)--that are processed by one of five kinds of operations--cognition (C), memory (M), divergent production (D), convergent production (N), or evaluation (E)--to yield one of six forms of products (response output)--units (U), classes (C), relations (R), systems (S), transformations (T), and implications (I). The permutation of one type of operation with one kind of content to generate one form of product constitutes a first-order ability factor. Central to the formulation of the 9 models in the investigation was the selection of 43 tests from the initial battery of 47 in the Sullivan et al. report. Set 1 (Models 1, 2 and 3) consisted of 23 tests reflecting cognition of behavioral content with the six products approximately equally represented. Set 2 (Models 4 and 5) included Set 1 with the addition of 14 tests reflecting the operations of cognition and convergent production of semantic content for all product elements except transformations. Set 3 (Models 6, 7, ,8 and 9) consisted of all tests represented in Sets 1 and 2 as well as 6 additional tests representing the cognition or convergent production of figural units, relations, or transformations. (See Appendix for the complete list of tests by set.) It should be mentioned that although the numbers of tests across the sets varied, the sample of 240 high school juniors remained constant. The research problem was explicated in two ways: (a) a description of each of nine models to be evaluated in terms of a

hypothesis to be tested regarding the presence of a first- or higher-order factor of interest and (b) statements of research questions relevant to each model.

## Method

Corresponding to the substantive emphasis was the translation of each of the 9 models into an appropriate measurement specification within the LISREL VI computer program (Jöreskog and Sörbom, 1984). Subsequent to the formation of the LAMBDA pattern matrix for each hypothesized model, estimates of loadings on the hypothesized factors (parameters) in each of the 9 models were obtained as were the intercorrelations among the factors within the PHI matrix. Four indicators of degree of fit--chi-square ($X^2$), a $X^2$/df ratio, a goodness-of-fit index (GFI), and a root mean square residual (RMR)--and one incremental improvement index, DELTA, were obtained to enable a comparison of the relative fit (explanatory power) of each of the models.

It should be mentioned that the mathematical model underlying this investigation in reality is not a higher order factor model despite the emphasis implied in the 9 models and the three research questions. What have been labeled higher-order factors were run in the LISREL VI program as first-order solutions prior to their being compared from one model to the other. The data presented in this investigation were not based upon a sufficient number of test measures to enable a clear definition of the BETA matrix required for a second-order LISREL function. The methodology for appropriate definitions of first- and higher-

order factor structures within models has been explicated by Marsh and Hocevar (1985).

## Results

The following outcomes are summarized:

1. Within each of the six measurement models representing hypothesized factor structures of substantive interest the dimensions emerging from the maximum likelihood confirmatory factor analyses reproduced the hypothesized structure with statistically significant ($p < .01$) loadings on every one of the test variables that had been specified to define a hypothesized factor.

2. For five measurement models involving two or more hypothesized factors intercorrelations among these factors corrected for attenuation typically were in excess of .80 with the lowest coefficient being .74.

3. Application of five indices of closeness of fit to the empirical results arising from the confirmatory maximum likelihood factor analyses of the six measurement models corresponding to hypothesized factor structures of conceptual interest yielded comparable results in achieving rank orders in goodness of fit of these alternative measurement models. (See Table 1.)

4. Specifically, Model 2, which consisted of six hypothesized first-order cognition of behavioral product factors, and Model 3, which comprised two hypothesized first-order product factors--one with the products of relations and the other with the products of transformations--and one second-order product factor made up of the remaining four products of the SI model, not only showed the

Table 1

Goodness-of-fit Results For All Models

| Model | NX | NK | df | $X^2$ | $\frac{X^2}{df}$ | Goodness-Of-Fit Index(GFI) | Root Mean Square Residual(RMR) | DELTA |
|---|---|---|---|---|---|---|---|---|
| Set 1 | | | | | | | | |
| 1 | 23 | 23 | 253 | 1475.53 | 5.832 | .406 | .247 | ——— |
| 2 | 23 | 6 | 215 | 274.6 | 1.277 | .913 | .047 | .814 |
| 3 | 23 | 3 | 227 | 291.98 | 1.286 | .908 | .048 | .802 |
| Set 2 | | | | | | | | |
| 4 | 37 | 37 | 666 | 3311.81 | 4.973 | .280 | .260 | ——— |
| 5 | 37 | 2 | 628 | 961.12 | 1.530 | .827 | .055 | .710 |
| Set 3 | | | | | | | | |
| 6 | 43 | 43 | 903 | 4058.93 | 4.495 | .260 | .254 | ——— |
| 7 | 43 | 1 | 860 | 1554.12 | 1.807 | .758 | .061 | .617 |
| 8 | 43 | 2 | 859 | 1426.34 | 1.660 | .786 | .059 | .649 |
| 9 | 43 | 3 | 857 | 1350.21 | 1.576 | .801 | .057 | .667 |

Note: NX = number of variables

NK = number of factors

closest degree of fit but also substantial promise in differentiating transformation and relation products from the other four products of units, classes, systems, and implications. (See Table 1.)

5. Although not yielding so close a degree of fit as the multifactor models, the model portraying a single general content factor accounted for a substantial proportion of the covariance among the test measures of social intelligence.

## Conclusions

The following conclusions evolved from the data analyses:

1. Application of confirmatory maximum likelihood factor analysis permitted the reproduction of hypothesized first- and higher-order factors within the social intelligence portion of the SI model.

2. Although the first- and higher-order product factors considered in the models concerned with the 23 measures of behavioral cognition were shown to be reproducible and statistically distinct, the high intercorrelations among the six first-order product factors and the high correlation between the single higher-order factors and each one of the two first-order product factors of transformations and relations would suggest that a single higher-order or general factor of behavioral content would constitute a viable alternative to account for much of the covariance among these tests of behavioral cognition.

3. The results of this investigation concerning first-order factors of social intelligence were not consistent with the first-order factors identified by O'Sullivan et al. (1965).

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## Appendix

Set 1 includes the following 23 tests:

Set 1

Cognition of Behavioral Transformations (CBT)

- 2 Cartoon Exchange (02CBT)
- 9 Expression Exchange (09CBT)
- 25 Picture Exchange (25CBT)
- 38 Social Translations (38CBT)
- 45 Who Said It? (45CBT)

Cognition of Behavioral Relations (CBR)

- 1 Cartoon Analogies (01CBR)
- 36 Silhouette Relations (36CBR)
- 37 Social Relations (37CBR)
- 40 Stick Figure Opposites (40CBR)

Cognition of Behavioral Units (CBU)

- 8 Expressions (8CBU)
- 11 Faces (11CBU)
- 16 Inflections (16CBU)
- 30 Questions II (30CBU)

Cognition of Behavioral Classes (CBC)

- 10 Expression Grouping (10CBC)
- 21 Odd Strip Out (21CBC)
- 26 Picture Exclusion (26CBC)
- 39 Sound Meaning (39CBC)

Cognition of Behavioral Systems (CBS)

- 12 Facial Situations (12CBS)
- 18 Missing Cartoons (18CBS)
- 19 Missing Pictures (19CBS)

Cognition of Behavioral Implications (CBI)

- 3 Cartoon Implications (03CBI)
- 4 Cartoon Predictions (04CBI)
- 31 Reflections (31CBI)

Set 2 Additional 14 tests:

14 Henmon-Nelson Vocabulary (14CMU)
17 ITED Quantitative Thinking (17CMS)
23 Pertinent Questions (23CMI)
24 Picture-Arrangement (24NMS)
27 Picture-Group Naming (27NMU)
32 Seeing Problems (32CMI)
33 Seeing Trends (33NMU)
34 Sentence Order (34NMS)
35 Ship Destination Test (35CMS)
42 Verbal Analogies I (42CMR)
43 Verbal Classification (43CMC)
44 Verbal Comprehension (44CMU)
46 Word Classification (46CMC)
47 Word Matrix Test (47CMR)

Set 3 Additional 6 tests:

7 DAT Abstract Reasoning (07CFR)
13 Figure Matrix Test (13CFR)
15 Hidden Figures (15NFT)
20 Mutilated Words (20CFU)
22 Penetration of Camouflage (22NFT)
41 Street Gestalt Completion (41CFU)